

Explaining Michelson-Morley without Special Relativity

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In this paper, we first discuss the concept of an emission wave. In the history of science, this is the first time we have discovered a new way in which (transverse) waves are realized in nature. It can therefore be expected to lead to important changes in the perspective about the nature of light or radiation. Then, we point out that the null result of the Michelson-Morley experiment is a natural and straightforward consequence of light being an emission wave. Concepts of special relativity, of length contraction and of time dilation, are not required for this explanation, however.

I. INTRODUCTION

The particle and wave concepts are, as is well known, not mutually exclusive always, but can be mutually supplementary. This is the case when, as an example, particles undergo oscillatory or wavy motion as a result of appropriate forces acting on them, and the wave can be looked upon as some disturbance propagating within a medium made up of those particles.

But, this supplementary nature of the particle and wave concepts does not validate itself for, in particular, radiation. No forces can be imagined to act on radiation (propagating in the vacuum), and the quanta of radiation cannot be imagined to undergo oscillatory motions.

With Louis de Broglie's seminal hypothesis that $\lambda = h/p$ for a body of momentum $p = mv$, the lack of this supplementary nature of the particle and wave concepts got extended to even material bodies of mass m .

In describing the *Fresh Fields* explored during the years 1926-27, the era of the development of the quantum theory, Heisenberg recalled [1] that: *Bohr was trying to allow for the simultaneous existence of both particle and wave concepts, holding that, though the two were mutually exclusive, both together were needed for a complete description of atomic processes.*

But, the question of why any “wave” associates with a quantum has not been addressed by this theory. In fact, it cannot be addressed within this framework, this being its assumption.

The “mutually exclusive” character of these two concepts, nevertheless, underlies the modern [2]

quantum theory, which further turned out to be an intrinsically probabilistic framework.

Bohr considered the particle and wave concepts as being “complementary” to each other. He then developed the principle of the complementarity of concepts as the Copenhagen Interpretation of the Quantum Theory.

II. CONCEPT OF EMISSION WAVE

But, any “other type of” supplementary nature of the particle and wave concepts, than that to be found within the considerations of Section §I, was not explored in the past.

Nevertheless, the following is the other type of the supplementary nature of the particle and wave concepts. ***This is, previously unrealized, new way in which wave phenomena happen.*** In the history of science, this is the first time we have discovered a new way in which (transverse) waves occur in nature. The associated mental picture is as follows.

Consider a hosepipe emitting water through its nozzle. Let the molecule of water move with some speed along a straight line after its emission at the nozzle and let its speed not change, unless that molecule happens to collide with another object along its rectilinear path of motion.

Change in the location of the nozzle also changes the flux of water passing location directly facing it. Any oscillatory motion of the nozzle then produces oscillatory change in the flux of water passing any location. The oscillatory changes in the location of the nozzle are “the cause” for the oscillatory changes in the jet of water.

No molecule is undergoing oscillatory motion. The oscillatory spatiotemporal changes in their flux exist, still. The particle and wave concepts are mutually supplementary, here.

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We will, henceforth, refer to this wave as an emission wave. Molecule of water can, clearly, be replaced by “the quantum” of any kind, even the massless one. Thus, the emission waves of quanta can get produced by their emitter, undergoing sort of an oscillatory motion.

The massless quanta can be assumed to be momentum-less, that is, as parcels of only energy. When emitted by a body, the direction of the emitted quantum can be assumed to be spherically symmetrically distributed around that instantaneous location of its emitter.

If the wave phenomena of radiation arise indeed due to aspects of emission of quanta, then such an origin must be consistent with Planck’s law. In other words, the aforementioned emission origin for the wave of radiation quanta or the concept of an emission wave needs to be consistent with the laws of the black body radiation.

As was shown in [3], this is indeed the situation. In summary, [3] showed the following.

From only statistical considerations, the average number of the quanta of radiation, of energy ϵ , in equilibrium within a cavity is given by

$$\langle n \rangle = \frac{1}{e^{\epsilon/kT} - 1}$$

On the other hand, the number of standing wave modes within the frequency range ν to $\nu + d\nu$, at frequency ν and enclosed within a cubical cavity of sides ℓ is

$$f(\nu)d\nu = \frac{8\pi\nu^2\ell^3}{c^3}d\nu$$

The spectral energy density of quanta contained within these modes is then:

$$\epsilon \langle n \rangle \frac{f(\nu)d\nu}{\ell^3} = \frac{8\pi\epsilon\nu^2}{c^3} \frac{d\nu}{e^{\epsilon/kT} - 1}$$

This last expression reduces to Planck’s formula for the spectral energy density of the black body radiation only when we assume $\epsilon = h\nu$.

However, the energy ϵ of a light-quantum is not related to the frequency ν of the wave of Light, for nowhere is this relation implied by this mechanism. Nevertheless, both the particle and wave pictures are implied by this mechanism, albeit in the roles supplementary to each other. Bohr’s point of view that the particle and wave pictures, both together, are needed for the complete description of atomic processes is clearly justified within this concept of an emission wave.

III. PROPAGATION OF EMISSION WAVE

Of very specific interest now is the fact that the emission wave does not require any “pre-existing

medium” for its propagation. This follows from the following considerations.

An emission wave propagates away from the nozzle, its source, only as the molecules of water propagate away from it. The wave gets “created” along with the emission of molecules at the nozzle and “propagates” along with them. Any prior existence of the “medium of water” is not necessary for the propagation of the emission wave.

This above is applicable to the emission wave of quanta. In particular, for the radiation quanta, this holds. The quantum of radiation can also be momentum-less and mass-less, as these properties are unrelated to the mechanism of the creation of the emission wave of such quanta.

IV. MICHELSON-MORLEY TYPE EXPERIMENTS

During the beginning of the twentieth century, certain experiments attempted detection of æther, the medium of propagation of light. The famous are the experiments of Fizeau, and of Michelson-Morley, which had relied on the phenomenon of the interference of light.

The reasoning underlying these experiments is that of the luminiferous æther being carried along with them by moving bodies.

If light were wave propagating within an existing medium of æther, then its speed in the direction of motion of the æther would be different than its speed opposite to the direction of motion of the luminiferous æther.

Then, if (monochromatic) light propagating in the direction of and that propagating opposite to the direction of motion of the æther were made to interfere in an interferometer, we would obtain the interference fringes due to the path difference induced by difference in the speed of propagation of light in these two situations.

If a dark fringe were to be prearranged in the interference apparatus, then we should detect shift in the fringe as the apparatus moves about in the space. Detecting this shift had been the aim of the experiments mentioned before.

As is well known, all these experiments did not detect any æther. The absence of the fringe shift in such experiments is then explained under the Lorentz transformations of space-time coordinates. This involves time-dilation and length contraction, the latter was first pointed out by Fitzgerald as a “natural consequence” of propagation of a body through the æther.

V. EXPLAINING MICHELSON-MORLEY TYPE EXPERIMENTS WITHOUT SPECIAL RELATIVITY

Now, for these experiments, we consider light as a monochromatic emission wave. The source of the light quanta is assumed to be oscillating, in this case, with a single frequency ν , and the quanta of light to be propagating with the speed of light (in vacuum), all. The frequency of the emission wave of light is then also ν .

Under the assumption that the quanta of light are mass-less, the speed of propagation of their emission wave is the speed of the quanta themselves. The velocity of mass-less and momentum-less quanta cannot be altered as per the concepts of Galileo and Newton. This velocity is the *same* for all the observers.

The emission wave of radiation propagates from the source to its reflector. On its reflection, the emission wave returns to the origin, and is made to interfere with the main wave. The speed of the emission wave is always the same, irrespective of the direction of its propagation, in vacuum and in any material like water in the case of Fizeau's celebrated experiment.

As no medium of propagation is involved, if the destructive interference is pre-arranged within the interferometer, then the dark line will not shift even if the apparatus, *ie*, the interferometer, were to move about in the space.

This is an explanation of the Michelson-Morley experiment. Clearly, we do not require the length contraction or time dilation (and the framework of the special relativity) to explain the results of the Michelson-Morley kind of experiments attempting

to detect the medium, luminiferous æther, of the propagation of light.

In 1927, Dirac stated [4] that *the light quantum has the peculiarity that it apparently ceases to exist when it is in ... the zero state in which its momentum, and therefore its energy, is zero. When a light quantum is absorbed it can be considered to jump into the zero state, and when one is emitted it can be considered to jump from the zero state to one in which it is in physical evidence, so that it appears to have been created.*

This picture is then needed along with the emission view for the wave of light, and the massless, momentum-less, nature for the energy quanta of light. The light beam reflected by the reflector is then produced as a result of the complete absorption of the energy quanta incident on it, and the total re-emission of the energy quanta constituting the reflected beam of light.

The mathematical framework underlying such processes is [5–10] that of the Universal Relativity. The details of this framework are however beyond the natural scope of the present discussion.

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